TIMSS SOUTH AFRICA WORKING PAPER SERIES

Investigating grade 9 mathematics achievement in the Western Cape and Gauteng: An analysis of TIMSS 2019

Joel Gondwe and Gabrielle Wills

The Human Sciences Research Council (HSRC) encouraged the secondary analysis of the Trends in International Mathematics and Science Study (TIMSS) South African data. Aspirant authors attended a series of TIMSS data analysis workshops to support their writing. The Working Paper series is intended to stimulate discussion and elicit comment. Reference in publications of the working papers should be cleared with the author(s).

The working papers are available online at https://www.timss-sa.org/publication-type/working-paper.

Disclaimer

The views expressed in this working paper are those of the author and not necessarily those of the HSRC or the Department of Basic Education (DBE).

Enquiries related to this working paper can be sent to Joel Gondwe at jrgondwe@gmail.com or Gabrielle Wills at gabriellewills@gmail.com.

Recommended citation

Gondwe, J. and Wills, G. (2022). Investigating grade 9 mathematics achievement in the Western Cape and Gauteng: An analysis of TIMSS 2019. TIMSS Working Paper Series. Human Sciences Research Council.

Investigating grade 9 mathematics achievement in the Western Cape and Gauteng: An analysis of TIMSS 2019

Joel Gondwe[1] and Gabrielle Wills[2]

May 2022

Abstract:

In the 2019 Trends in International Mathematics and Science Study (TIMSS), two of nine South African provincial education departments sought to increase the precision of their performance estimates through the participation of a larger school sample. This enables the comparison of students' mathematics performance in these two provinces against each other and against the combined performance of seven remaining provinces. Using these data, we identify relative system efficiencies at work in Gauteng and the Western Cape as reflected in notably higher levels of grade 9 mathematics achievement in these provinces compared to seven other provinces, after accounting for student compositional and school resourcing differences. In no-fee charging schools, a significant learning advantage in favour of Gauteng and particularly the Western Cape relative to seven other provinces is evident among equally poor students with similar school and home background characteristics. Importantly though, provincial performance gaps are much larger if socio-economic and home background differences across students are not accounted for. A learning improvement agenda, including active measures to improve the quality of teaching in schools supported through functional administrations, should happen in parallel with a programme of economic growth and poverty alleviation. Notwithstanding, the Gauteng and particularly the Western Cape advantage in no-fee schools is evidence that education systems can do better with what they have and given the poverty levels of the children they serve. Yet, international comparisons imply that even these better performing provinces could improve. This points to the continued importance of the development of state capability across all education departments in shaping the effectiveness of schooling.

[1] Post-doctoral researcher at Research on Socio-Economic Policy (ReSEP), Stellenbosch University. Corresponding author (joelgondwe@sun.ac.za)

[2] Researcher at Research on Socio-Economic Policy (ReSEP), Stellenbosch University.

The authors wish to acknowledge inputs on earlier drafts of this paper from colleagues at Research on Socio-Economic Policy including Alex O'Riordan, Servaas van der Berg, Heleen Hofmeyr and Debra Shepherd. Comments from reviewers are also very much appreciated.

1. Introduction

The Western Cape and Gauteng education systems have for a long time been two of the best performing provinces in South Africa as measured by performance in high-stakes matriculation examinations (Reddy et al., 2020). The relative performance of these systems has been a point of political importance for the two provinces, where the Western Cape is the only province to be led by the opposition party. However, rankings across provinces have tended to vary across educational outcomes (Department of Basic Education, 2016) and by age, grade or across different points in the socio-economic distribution. As an example, at the primary level (grade 6), the Western Cape was achieving higher literacy and numeracy outcomes among the poorest of students compared to equally poor students in Gauteng (Wills, Shepherd & Kotzé, 2018). In contrast, with respect to grade 9 mathematics outcomes, the levels of improvement in student achievement that were evident in other provinces are not necessarily observed in the Western Cape, possibly as the results are coming off a higher base level (Department of Basic Education, 2016, 2020).

Although matriculation outcomes are a key metric for provincial comparisons– and a politicised one - this is an insufficient measure of system performance. Over half a million students that started in grade 1 twelve years earlier have already dropped out of school by the time they reach matric and are thus not evaluated in these end of school examinations. System-wide assessments are required at earlier grades, and particularly before grade 10 when drop-out becomes prevalent (van der Berg et al 2018). However, provincial comparisons of learning at earlier grades have been constrained by limited sample sizes, calling into question the validity of existing comparisons of learner performance before the end of schooling. As a response, in the 2019 grade 9 Trends in International Mathematics and Science Study (TIMSS) – an international assessment of mathematics and science – the Western Cape and Gauteng sought to increase the precision of their performance estimates by increasing their sample sizes (Reddy et al., 2020; Human Sciences Research Council, 2019). This allows for a better comparison of these provinces' performance not only to each other, but also relative to the remaining provinces. Using these data, we aim to answer three main research questions:

i) Is there a learning advantage in mathematics to being in the Gauteng or Western Cape school systems relative to attending schools in other provinces in South Africa?
ii) How does students' mathematics performance compare across Gauteng and the Western Cape?
iii) Are learning advantages across provinces explained away by differences in student home background or school resourcing contexts?

In relation to the third question, student performance across South Africa's nine provinces cannot be compared appropriately without being sensitive to significant differences in student's home background factors or differential access to resources. Better academic outcomes in the Western Cape or Gauteng may simply be the consequence of students' home background support for learning, more resourced schools, prior access to early childhood development or other home-related enablers for development. In a context where TIMSS

results can provide important information on the efficiency of education systems, in turn fostering accountability for improved education service delivery, as best as possible effort should be given to making fair comparisons across systems. Building on earlier work by Wills et al. (2018), we take advantage of the larger TIMSS 2019 grade 9 samples and perform a more detailed and up-to-date comparison of mathematics performance in South Africa.

Specifically, we conduct a descriptive analysis aimed at investigating how the Western Cape and Gauteng perform, first comparing the two provinces to each other, and then comparing them to the remaining seven provinces. We aim to explore how differently the Western Cape (or Gauteng) performs on mathematics assessments after we control for differences in the socio-economic profiles of students, other home background factors, social interaction factors, teacher and classroom resources, school and institutional factors, and levels of parental involvement.

The remainder of the paper is structured as follows. In the next section a brief literature review is provided that situates the discussion on performance differentials in a broader provincial and historical context. Section 3 discusses the data to be used, while section 4 gives attention to identifying descriptively how mathematics outcomes differ across provinces. Section 5 is dedicated to identifying how provinces – and students in those provinces - differ in systematic ways and explains how we control for these differences in an econometric analysis of learning outcomes. Regression results are provided in section 5.3 and section 6 concludes.

2. Background and literature review

At the dawn of democracy, the 1996 South African Schools Act (SASA) laid out reforms for South African education. SASA replaced fragmented and racially-defined institutional arrangements with a multi-tiered system of education. Although policy-making, establishing regulatory frameworks and overall responsibility for resourcing was allocated to the national-level, implementation was assigned to the nine provinces. Provinces were given authority for how budgetary resources for education were to be spent, employing teachers and other education personnel, as well as establishing lines of accountability between schools and government. With this decentralization of education service delivery, differences in system functioning and ultimately learner performance are to be expected across provinces.

2.1 Provincial indicators of educational outcomes

In an earlier provincial education comparison of student performance, it was pointed out that while the Western Cape Education Department (WCED) is *a* best performing provincial department with respect to observed student outcomes, it is not consistently *the* best performer (Wills et al, 2018). On this wise, the authors cite examples such as the constrained ability of the Western Cape educational department to convert school learning into school completion rates in the form of youths passing the National Senior Certificate (NSC) – a necessary qualification, impacting both on students' access to further tuition and earnings potential in the labour market (Department of Basic Education, 2016).

More recent sector reports and strategic plans produced within the Department of Basic Education (DBE), provide useful information on educational outcomes across provinces using a plethora of assessments. Figure 1, taken directly from a recent DBE (2020) sector plan, provides a comparison of provincial performance on eight different learning outcomes spanning the primary and secondary school years expressed on a consistent standardised scale. Included are metrics of TIMSS 2015 grade 9 results, grade 6 SACMEQ[3] 2013 mathematics results, and grade 4 performance in PIRLS[4] 2016. Three indicators of school leaving outcomes are also considered, including bachelors passes in the NSC and high-level NSC outcomes (in mathematics and science) expressed relative to the provincial population of 18-year-olds.

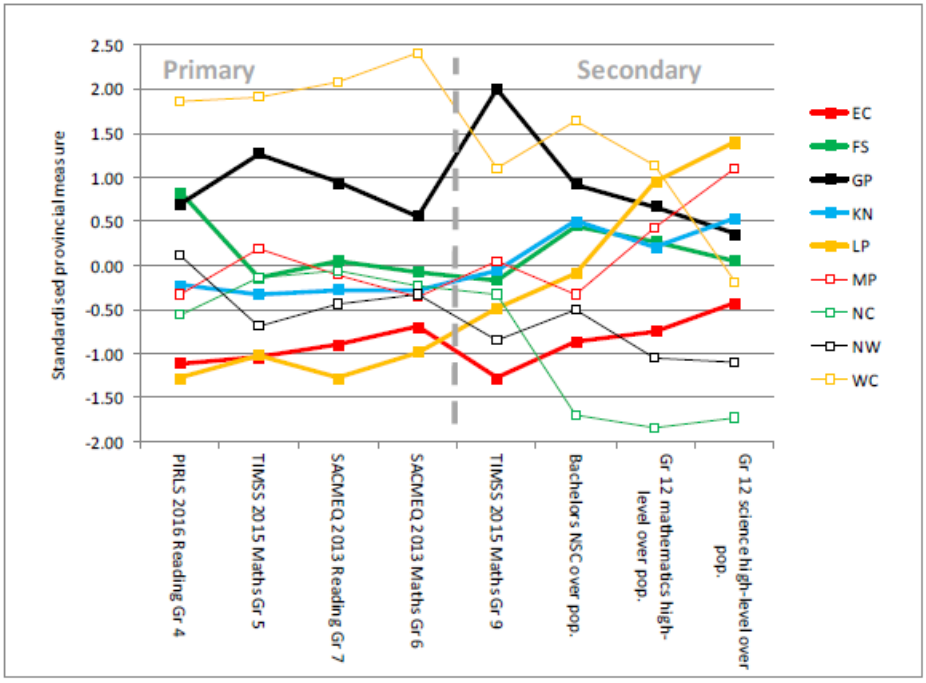
Two features of the graph are evident. First, overall Gauteng and, particularly, the Western Cape are significantly better performers than other provinces, with average Western Cape performance exceeding the performance of Gauteng in the primary grades. However, these patterns shift in the secondary phase. The Western Cape produced the highest relative number of bachelors passes in the NSC on average between 2016-2018 as a proportion of the provincial population of 18-year-olds yet fares poorly relative to other provinces with respect to high-level science passes. Not shown in this figure, grade 12 passes in the Western Cape relative to the population of youth have also been quite low relative to Gauteng or even relative to weaker performing provinces such as Limpopo (Department of Basic Education 2016:43).

In grade 9 TIMSS 2015, the performance advantage was also in favour of Gauteng rather than the Western Cape as seen in Figure 1. Yet average grade 9 mathematics results in the Annual National Assessments from 2011 to 2014 implied an advantage to the Western Cape. From 2015 to 2019, however, the TIMSS provincial ranking changed indicating that performance efficiencies are neither static nor fixed. By implication system improvements in learning are possible.

[3] Southern and East African Consortium on Measuring Educational Quality (subsequently abbreviated as SEACMEQ).

[4] Stands for Progress in International Reading and Literacy Study.

Figure 1: Overall view of the learner performance by province



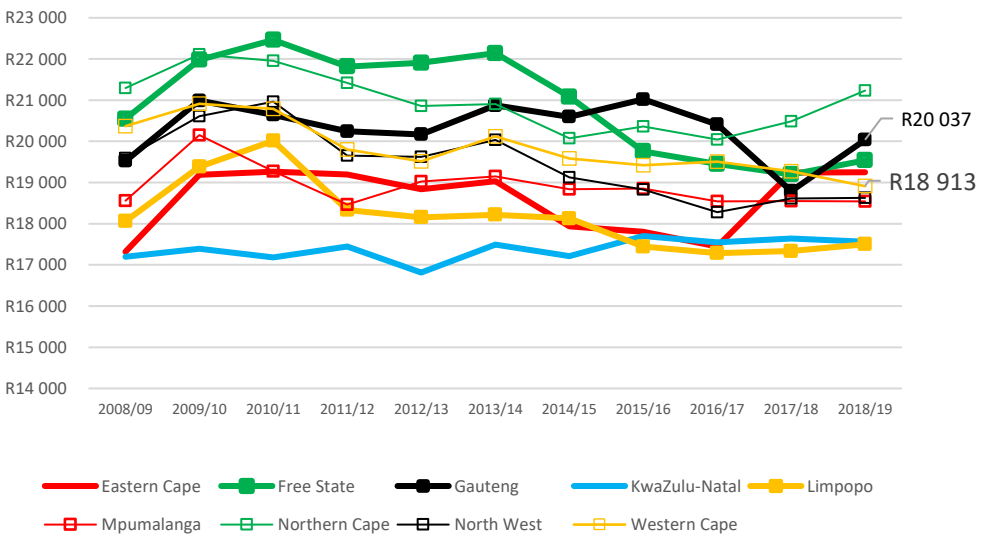
Source: Department of Basic Education (2020:89). Notes from source: Provincial performance values were adjusted to give a mean of zero and a standard deviation of 1 across the nine (unweighted) provinces. Original PIRLS values are those seen in Howie et al (2017: 50). Mean TIMSS Grade 5 values are those seen in Table 1 of DBE (2020), SACMEQ values are 2013 values from Table 8 and Table 9 of DBE (2020), TIMSS Grade 9 values are 2015 values from Table 11 of DBE (2020), Bachelors-level values are from Table 5 of DBE (2020), and Grade 12 mathematics and physical science values are from Table 7 of DBE (2020).

2.2 Public education spending: Current patterns across provinces

It is clear from the preceding discussion, that the Western Cape and Gauteng are better performing systems, with an overall performance advantage in favour of the Western Cape. What may account for these differences? The first place to turn in answering this question is evaluating how educational spending differs in these provinces.

Despite alleged equal funding per child in the national funding formulas, national averages hide underlying heterogeneity between provinces as described in work by Spaull et al (2020). Figure 2 shows per learner expenditure in 2018 prices (adjusted using a Basic Education Price Index) for nine provinces from 2008/09 to 2018/19. Despite an equalising in public spending over this period, just before TIMSS 2019 was administered, annual spending per learner in Gauteng was higher at R20 037 than in the Western Cape at R18 913 – a difference of about 6 percent. Public spending per learner in the Western Cape was, however, still higher relative to North-West, Mpumalanga and particularly KwaZulu-Natal and Limpopo provinces.

Figure 2: Final per learner current expenditure, real 2018 Rands (using BEPI-Persal)



Source: Spaull, Lilenstein and Carel (2020:32). Notes: BEPI stands for Basic Education Price Index

Although provincial deviances in current per learner expenditure exist, they are arguably not large enough to explain differences in system performance across provinces. However, as explained later (see section 2.3.2.), the persistence of historical inequalities in spending are still likely to play a role in current system performance.

2.3 Socio-economic, political and institutional contexts

In the econometric analysis to follow, we focus on proximal determinants of educational performance that may explain some of the provincial differences in educational outcomes. In estimating grade 9 mathematics, proximal determinants such as student, school, classroom and teacher factors are identified from the TIMSS contextual questionnaires. However, as Levy (2018) explains, divergent socio-economic, political, and institutional contexts shape the performance of education bureaucracies through their influence on the formation of governance arrangements. Governance arrangements expressed through 'incentives, constraints, rewards and sanctions of a system's participant' (Levy, 2018:257) shape the efficiency and effectiveness with which resources are used to achieve outcomes. Levy (2018) also strongly emphasises the complementary role of local accountability, such as strong parent governing board associations in providing additional capacity for school effectiveness. Gustafsson (2019) in response further emphasises that it is state capacity in the administration of schooling systems, that significantly shapes the effectiveness of schooling. Building state capacity 'requires a logical organisational structure, systems of incentives for officials, robust information systems, necessary financial controls, good public communication arrangements, and so on' (Gustafsson, 2019:2).

However, many of these arrangements, whether political, institutional contexts or accountability processes are seldom captured in school survey data (or any data), so that investigating proximal determinants alone is unlikely to capture the full extent of differential provincial functioning (Pritchett, 2019). In the next section, we therefore provide background

context on current and historical factors that have shaped the differential functioning of provincial education.

2.3.1 Governance arrangements

In Gauteng, and particularly the Western Cape, socio-economic, political and institutional contexts establish a platform for relatively strong bureaucratic capability for public provisioning of services. In an analysis of the functioning of the WCED relative to a much weaker functioning Eastern Cape Department of Education (ECDE), Levy's (2018) mixed methods analysis concludes that the WCED succeeds in the core tasks of bureaucracy: managing resources, assigning personnel to where they are most needed; monitoring and managing on the basis of performance. On an annual basis the Auditor General conducts department audits to identify areas in which accountability, governance and oversight needs to be enhanced across the education and training value chain.[5] The WCED in the 2015/16 and 2016/17 years was the only education department to receive an unqualified audit (Auditor-General South Africa, 2016).

With respect to the Gauteng Department of Education (GDE), Gustafsson and Taylor (2018) conclude that this is a considerably more efficient education system than comparator provinces when measured by matriculation outcomes. They maintain that these efficiencies are exogenous[6] to student's home background. In their quasi-experiment involving the shifting of provincial boundaries, the authors compare matriculation outcomes in schools before and after the boundary change. Schools that moved under the governance of Gauteng province, experienced notable improvements in matric performance.

In the area of governance, a key aspect in which the Western Cape and Gauteng stand out, is in their management of personnel, applying more innovative and strategic approaches and being open to new models of working. Box 1 distinguishes how the GDE and WCED differ from other provinces in this regard.

[5] The audits focus on programmes and initiatives receiving significant public resources in line with the goals of the National Development Plan.

[6] An exogenous variable in the context of regression analysis is a variable which is not affected by other variables.

Box 1: Management of personnel in the GDE and WCED

- **Post establishments[7] set within public budget limits:** The GDE's and the WCED's management of the education personnel budget has been known to guard against crowding-out spending on important non-personnel inputs such as learner and teacher support material. These have been the only two provinces that determine post establishments within available budgets (a practice that has not been shared by seven other provinces), rather than allowing existing post establishments to determine spending (Deloitte, 2013). This, coupled with the likelihood that wealthier schools are considerably more likely to enjoy the services of publicly paid non-educators (such as grounds staff, cleaners and school administrators), Western Cape and Gauteng schools are more likely to be resourced with support staff, creating a platform for improved administration and governance at the school level.
- At the level of **managing teacher performance**, however, the Western Cape has arguably done better than Gauteng within the bounds of utilising the existing teacher performance management system, in the form of the Integrated Quality Management System (IQMS). Although, Gauteng is far more lenient than any other province in applying the system, despite assigned ratings of performance having some bearing for small performance incentives.[8]
- **Innovative contracting of officials in Gauteng:** The GDE has engaged in innovative, performance enhancing contracting in the administration, particularly in relation to the top 100 earning non-educator employees in the province (Gustafsson and Taylor 2018; Department of Basic Education, 2020).[9]
- **Principal competency testing:** Gauteng and the Western Cape are the only two provinces with some experience experimenting with competency tests in the hiring of school principals. This is a necessary step in the principal hiring process because once principals are appointed, they tend to remain in the same school for a long period (Wills, 2015).

2.3.2 Historical inequalities in spending and system performance

The functioning of provincial education departments can also be viewed as entrenched in historical inequities in education spending and apartheid racial desegregation in education programming, with strong geographical delineations that align to current provincial boundaries.

Despite the equalisation of school spending in post-apartheid South Africa, Crouch and Hoadley (2018:16) draw attention to how "apartheid inheritance disproportionately favoured Gauteng and the Western Cape". In 1990/91 for example, education expenditure in these provinces was two to three times higher per learner compared to the Eastern Cape as seen in Table 1 which draws from estimates in a Department of Education (2006) report. By 2004/05 intra-provincial

[7] Post establishments refer to the personnel resources in the form of teachers, management staff and support staff that are allocated to schools through specified formulas.

[8] For example, between 2011 and 2013, in around 65 percent of schools in the Free State and Western Cape there were no 'outstanding' educators. In Gauteng, around 65 percent of schools *had* 'outstanding' educators.

[9] If one looks at the top 100 non-educator employees, in terms of earnings, in each of the province's education departments, the general trend is for between 90 percent and 100 percent of people to have permanent job tenure during the last decade. In Gauteng, whilst this situation prevailed in 2005, the province subsequently reduced the percentage of permanent employees amongst its top 100 earners rather substantially, to 74 percent in 2008, and then 59 percent by 2011" (Department of Basic Education, 2020).

inequalities had drastically reduced through pro-poor public spending as reflected in reductions in measures of spending inequality (the Gini coefficient). This dramatic improvement in equalising spending was reflected earlier in Figure 2, where per learner government expenditure in the Eastern Cape was in fact higher than in the Western Cape in 2018/19.

Table 1: Public ordinary school expenditure per pupil, by province 1990-2004, and its inequality, national base of 100 in each period

	1990/91	2000/01	2004/05
EC	78	93	95
FS	104	109	116
GP	154	123	108
KN	80	87	92
LP	74	92	92
MP	86	93	102
NC	153	135	112
NW	88	111	112
WC	180	117	109
Total	100	100	100
Gini	0.39	0.09	0.08

Source: Department of Education (2006: 36.)

In former boundary areas that overlap with Gauteng and the Western Cape, apartheid institutional arrangements inherited by post-apartheid administrations were more established and conducive to better future functioning systems compared with other provinces. For this reason alone, one would expect to observe learning effects in Gauteng and the Western Cape after controlling for observed proximal determinants of learning.

3. Data and approach

To answer the three main research questions outlined in the introduction of this paper, we primarily draw on TIMSS 2019. Since inception in 1995, TIMSS assessments have been conducted every four years with the most recent published results available for 2019, involving 64 countries and 580 000 students worldwide (Mullis et al. 2020). In South Africa, TIMSS has been successfully administered by the Human Sciences Research Council (HSRC) in all the years South Africa participated in the assessments.[10] While these assessments are typically administered to fourth and eighth grade students, this has not always been the case in South Africa. Instead, the country participated at the grade 8 level in the 1995 through 2003 cycles, and at the grade 9 level in the 2003, 2011, 2015, and 2019 cycles (Reddy et al., 2020).[11]

In South Africa, TIMSS is stratified by province – of which there are nine. In 2019, the Western Cape and Gauteng sample sizes were increased from a typical sample of 30 schools, to a larger provincial sample size of 150 schools each (Reddy et al 2020).[12] As a consequence, Western

[10] Except in 2007 when South Africa did not participate in TIMSS.

[11] Meanwhile, the 2003 TIMSS included assessments from both Grade 8 and 9 students.

[12] For a detailed report on the TIMSS methodology including survey design see Martin, von Davier and Mullis (2020).

Cape and Gauteng effectively made up approximately 58 percent of the total South African school sample. The analysis presented in this section specifically exploits these larger sample sizes to compare learner performance in mathematics in these two provinces against each other, but also against the combined performance of the seven other provinces. In this 2019 round, the TIMSS assessments were conducted in 519 schools and among 20 829 students, while the contextual tools were administered to 543 mathematics teachers, and 519 school principals. TIMSS data is specifically utilised to leverage the availability of the following information:

1. The student mathematics score which is transformed to have a mean of 500 and a standard deviation of 100. This score is calculated as an estimate of latent proficiency and ability using imputed values known as plausible values (von Davier, 2020). These (five) plausible values when taken together resemble individual test scores and have approximately the same distribution as the latent variable being measured (Mislevy, 1991; Mislevy, Johnson & Muraki, 1992). These plausible values can be used to calculate unbiased estimates of group characteristics such as means and variances (Wu, 2005).
2. The share of students reaching the TIMSS international performance benchmarks.
3. Student information which crucially includes information on household possessions which can be used to create an asset index proxying for socio-economic status (SES).
4. School level administrative data.

The second data source used is the 2014/15 Living Conditions Survey (LCS) which was conducted by Statistics South Africa (StatsSA) with the aim of better understanding living conditions and poverty in South Africa. The survey collected data from 27 527 households which represented a sample size of about 88 906 individuals. This survey is utilised solely for its information on household expenditure, which is used to link the derived SES-scale to a log of consumption scale as discussed in Section 5.3, following the methodology of Kotze and van der Berg (2019). In the next section, we use descriptive methods to explore how students' mathematics performance compares across Gauteng, the Western Cape and seven other provinces. As a first attempt at identifying whether learning advantages across systems may be attributed to socio-economic differences across students, non-parametric regression analysis is used to compare (across provinces) levels and gradients in the relationship between students' mathematics performance and SES using comparable measures of wealth. To further answer research question three, we then extend the analysis with multivariate estimations to assess whether learning advantages remain after accounting not only for socio-economic differentials, but differences in classroom, teacher, school, parent and other broader institutional factors.

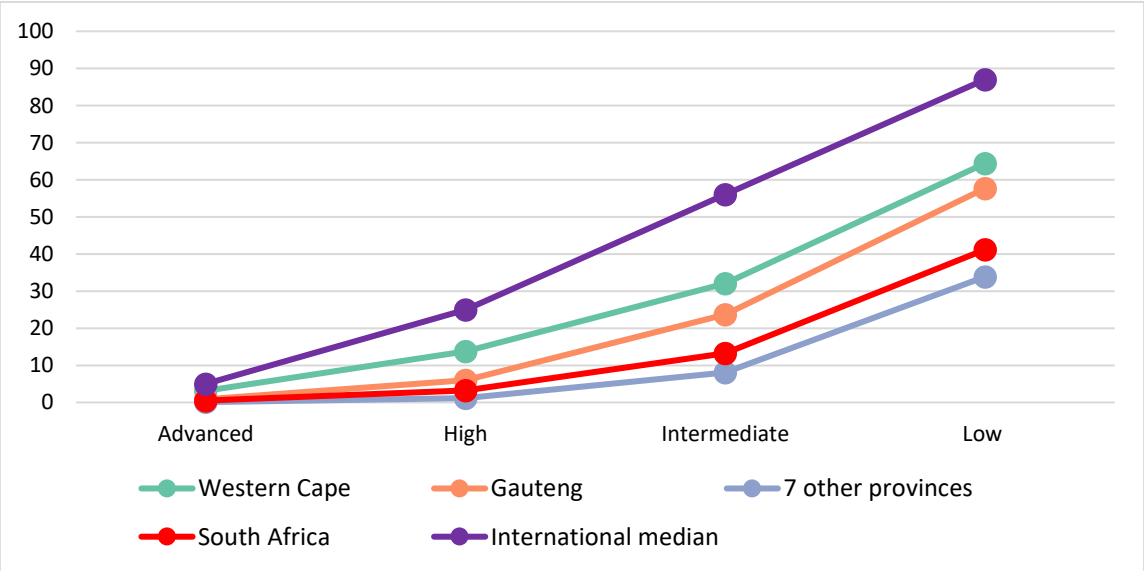
4. Is the Western Cape in the lead? A descriptive analysis

4.1 A comparison against TIMSS benchmarks

As the bulk of the discussion in this section concerns itself with cross-regional comparisons of TIMSS performance, we briefly give attention to the meaning of the Item-Response Theory (IRT) scores which are presented on a transformed scale. For example, what does a student who scores 500 actually know, and what is the student able to do? To aid interpretation, TIMSS identify four international benchmarks along the IRT scale: the advanced (a score of 625), high (550), intermediate (475), and low (400) international benchmarks (refer to TIMSS 2019 International Results (Mullis et al. 2020)). Students that reach a score of 400 have demonstrated only some knowledge of whole numbers and basic graphs while those that reach a score of 475 can apply basic mathematical knowledge in a variety of situations. In contrast, students who reach a score of 550 can better apply their understanding and knowledge in a variety of relatively complex situations. Finally, those that reach 625 on the assessment scale not only possess better understanding of the subject matter but can also apply and reason in a variety of problem situations, solve linear equations, as well as make generalisations.

Figure 3 identifies the percentage of the sample population that reaches a particular benchmark in the Western Cape, Gauteng, and in seven other provinces.[13] The South African average is also shown and the median for all countries participating in TIMSS 2019. Figure 4 then identifies what percentage achieve a score that is between chosen benchmark points (i.e. 0 - 399, 400 - 474, 475 - 549, and 550 and above).

Figure 3: Percentages of students reaching international benchmarks of mathematics achievement, grade 9 TIMSS 2019

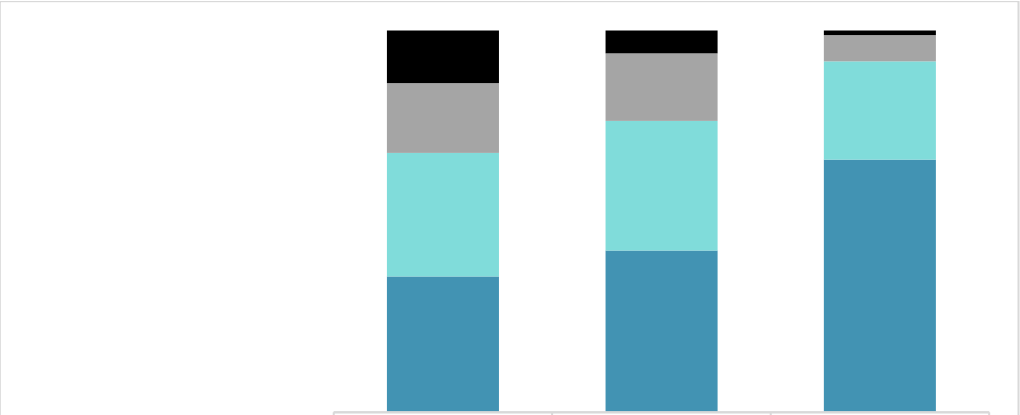


[13] Confidence intervals are drawn for each benchmark but due to their small sizes are not visible.

Whereas up to 64 and 58 percent of students from the Western Cape and Gauteng reach the low benchmark respectively, only 33 percent of students from the remaining seven provinces reach this low benchmark (see Figure 3). Worse still, this is far below the international median where 87 percent reach the low benchmark. As shown in Figure 4, up to 66 percent of the sample population of the seven other provinces do not even reach the minimum competency threshold of 400 points on the assessment scale. Thus, even after spending nine years in formal learning, the majority of grade 9 students in the seven other provinces combined still do not have a basic understanding of whole numbers and graphs.

Just 1 percent of South African grade 9 students meet the advanced benchmark, with low shares meeting this advanced benchmark in all provinces. Compared with the seven other provinces and even Gauteng, a notably higher share of students in the Western Cape (14 percent vs 6 percent in Gauteng and 1 percent in other provinces) meets at least the high benchmark, as seen in Figures 3 and 4. The Western Cape and Gauteng education systems have much higher shares of students reaching at least the intermediate benchmark, though the Western Cape also performs marginally better by this metric. Unfortunately, in the remaining seven provinces just over 7 percent of their students reach this same intermediate benchmark.

Figure 4: Percentage in each international benchmark range for mathematics, grade 9 TIMSS 2019 South Africa



	Western Cape	Gauteng	Others
High and advanced (>550)	14%	6%	1%
Intermediate (475-549)	18%	18%	7%
Low (400-474)	32%	34%	26%
Below low (<399)	36%	42%	66%

Yet grade 9 mathematics performance in the two better performing provinces compare poorly relative to the average performance of participating countries in the TIMSS sample (albeit with a large representation of developed nations). The international medians for reaching different TIMSS benchmarks depicts considerably higher levels of mathematics performance internationally when compared to Gauteng and the Western Cape student samples, even though other countries participate at the grade 8 rather than grade 9 level.

Given this backdrop, we move into a discussion of mean performance. Before doing so however, we draw attention to points of caution. There is a tendency in education related research to merely compare raw average student assessment scores which are then used to rank education systems in 'league tables' (Ross & Zuze, 2004). This is problematic for two reasons.

First, as these averages are calculated from population samples, albeit randomized and representative, they are nonetheless sample averages and would therefore suffer from having high levels of variation around the mean from one sample to the next. An appropriate workaround is to either report the sample mean with its associated standard error, or to use confidence intervals. Using the confidence interval assists in assessing the sample mean's precision by providing a range of scores within which one is 'confident' that the true population mean lies. Where two confidence intervals overlap, any difference in the means is likely reduced to non-significance.

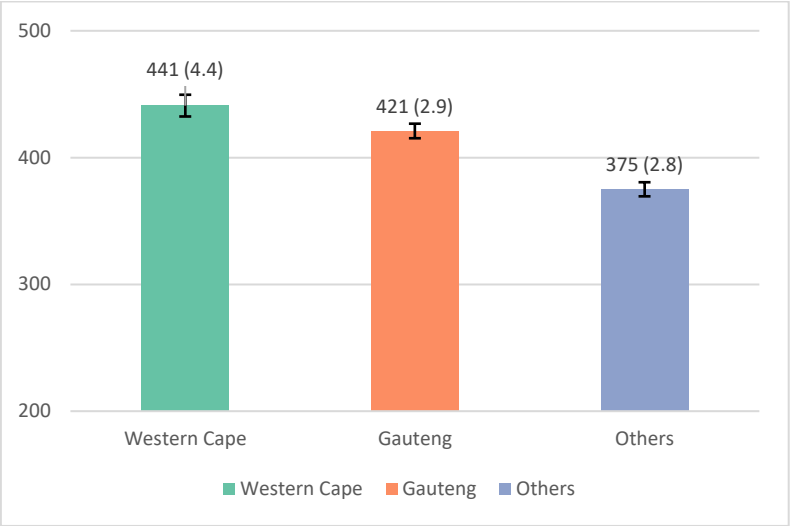
The second drawback of the league table approach is that it neglects a universal finding that children from high socio-economic backgrounds tend to outperform their counterparts from lower socio-economic backgrounds. This may be due to several factors such as increased exposure among lower SES students to adversity at a younger age which is linked to decreased educational success (Shonkoff & Garner, 2012), as well as lack of access to information about available education opportunities (Brown, Wohn & Ellison, 2016). Low SES students also tend to have less access to family resources, experiences and other advantages in early life that foster the development of fundamental skills (Bradley et al., 2001; Aikens & Barbarin, 2008; Buckingham, Wheldall & Beaman-Wheldall, 2013; van Bergen et al., 2017).

In South Africa, a country renowned for having one of the highest levels of income inequality in the world (Francis & Webster, 2019), it would be remiss to report and rely heavily on mere raw averages that neglect the role of either school or family SES. Therefore, in addition to a discussion based on mean performance, descriptive results from a local polynomial regression are also presented that account for students' social background.

4.2 Provincial and demographic comparisons of student performance in South Africa

Consistent with having a larger share of students reaching the high international benchmark, students in the Western Cape on average perform better than students in other provinces as seen in Figure 5. Whether compared to Gauteng, or to the remaining seven provinces, mean performance is significantly different, seen in how confidence intervals do not overlap at any point.

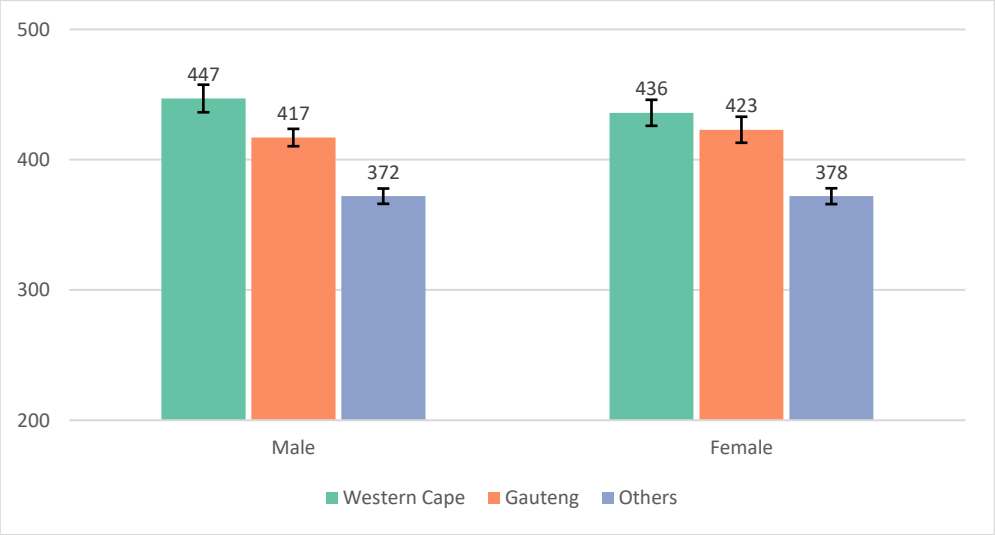
Figure 5: Mean student performance in mathematics by province, grade 9 TIMSS 2019



Disaggregated by gender, performance differences in mathematics are also noted across the three different regions. Figure 6 shows that grade 9 boys in the Western Cape perform significantly better in mathematics tests than boys in Gauteng and in the remaining seven South African provinces. Furthermore, while the average performance differential across Western Cape and Gauteng female students is not statistically different (at least at the 5 percent level of significance), female grade 9 students in the Western Cape and Gauteng performed significantly better than female students from the remaining provinces.

While the average student score in the Western Cape may be high, this says nothing about the distributional equity of test scores among students in these regions. That is, how much worse off do poorer students perform relative to wealthier students across provinces? In an ideal situation, one wants the spread of that distribution to be smaller, thus implying a more equitable distribution of test scores.

Figure 6: Mean mathematics performance by gender and province, grade 9 TIMSS 2019

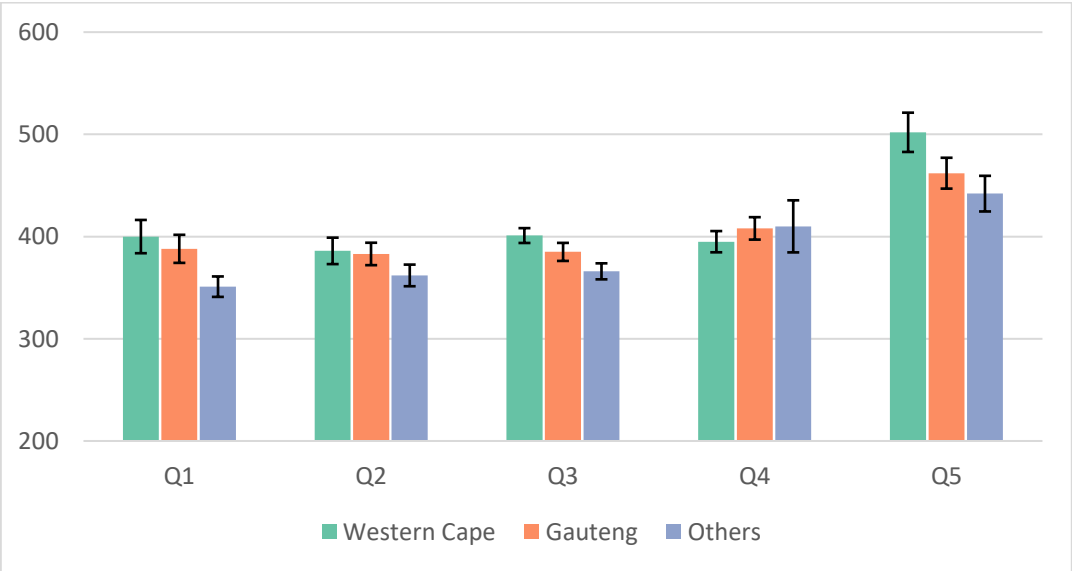


As a proxy for economic well-being, the DBE calculated a poverty index for each public school according to the poverty of the community around the school, as well as specific infrastructural factors (Reddy et al., 2020).[14] This poverty index is then used to categorise schools into five (unequal) groups, where quintile 1 reflects the least resourced schools, and quintile 5 the most resourced schools. Quintiles 1 to 3 schools are typically no-fee charging schools, while quintiles 4 and 5 schools are allowed to charge fees.

Figure 7 shows how the average mathematics achievement in each quintile category differ by location.[15] The same information is then presented in a different way in Figure 8 to emphasize how students perform within the same location but in each of the school quintiles. What is immediately apparent in these figures is that student performance in quintile 5 schools is better than student performance in quintiles 1-4 schools, irrespective of provincial location. This merely reflects that students in more affluent schools generally outperform their peers in schools in poorer communities.

In a comparison of performance in no-fee schools (quintiles 1-3), there is a clear advantage to the Western Cape and Gauteng compared to the seven other provinces. Although this advantage is not evident among student samples in quintile 4 schools. We also highlight that while the average mathematics scores of the Western Cape student sample are higher than in Gauteng for all quintiles, this advantage is only statistically significant in quintile 5 comparisons. In section 5.3.2, we subsequently find that this advantage among quintile 5 students is accounted for by compositional differences across students. By contrast, a simple descriptive comparison of TIMSS performance across no-fee schools in Gauteng and the Western Cape, hides a slight advantage in favour of the Western Cape as discussed in section 5.3.2.

Figure 7: Mean student performance by quintile and location

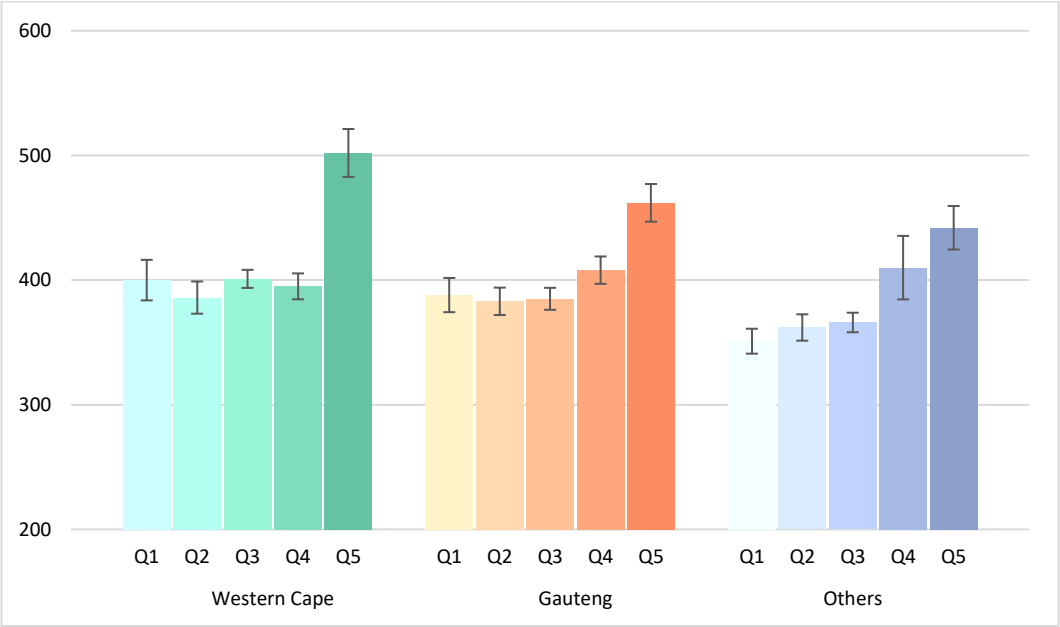


Notes: Results for independent school samples not shown due to smaller sample sizes.

[14] Note that up to 95 percent of students in the South African schooling system learn in public schools implying that this derived poverty index represents the majority of the South African student population (Reddy et al., 2020).

[15] Independent schools are not reported on here due to small sample sizes (Reddy at al 2020).

Figure 8: Mean student performance by location and quintile



Notes: Results for independent school samples not shown due to smaller sample sizes.

4.3 Socio-economic learning profiles

Using school quintiles, Figures 7 and 8 succeed in demonstrating that students from the wealthiest school environments and neighbourhoods outperform their poorer counterparts. It is possible though that between provinces the SES of students within school quintiles may differ. In examining more carefully the association between SES and student's mathematics performance, we use a non-parametric technique in the form of a kernel-weighted local polynomial regression (Fan & Gijbels, 2018). This is a graphically intuitive approach to assess how students perform along the socio-economic profile. This technique has the advantage of allowing the data to 'speak for itself' and thereby showing the 'true' mapping of SES and student performance by carrying out locally weighted regressions at each data point and then smoothing the result through the weighting system.

Following Filmer and Pritchett (2001), an SES index is constructed from student questions on household possessions to which Principal Component Analysis (PCA) is applied. The result is a SES index that is transformed to have a mean of zero and a standard deviation of 1. As a sensitivity check, this asset index is linked to another wealth indicator measured in log of per capita consumption as discussed in Kotze and van der Berg (2019). The reason for this, is that traditional asset-based indices are known to be sensitive to context. For example, in reflecting a level of wealth, owning a bicycle in a wealthier country context may be quite different from owning a bicycle in a poorer context. The asset measures can therefore be difficult to use when comparing students from different areas (Vyas & Kumaranayake, 2006).

Figure 9: Student distribution by SES and province

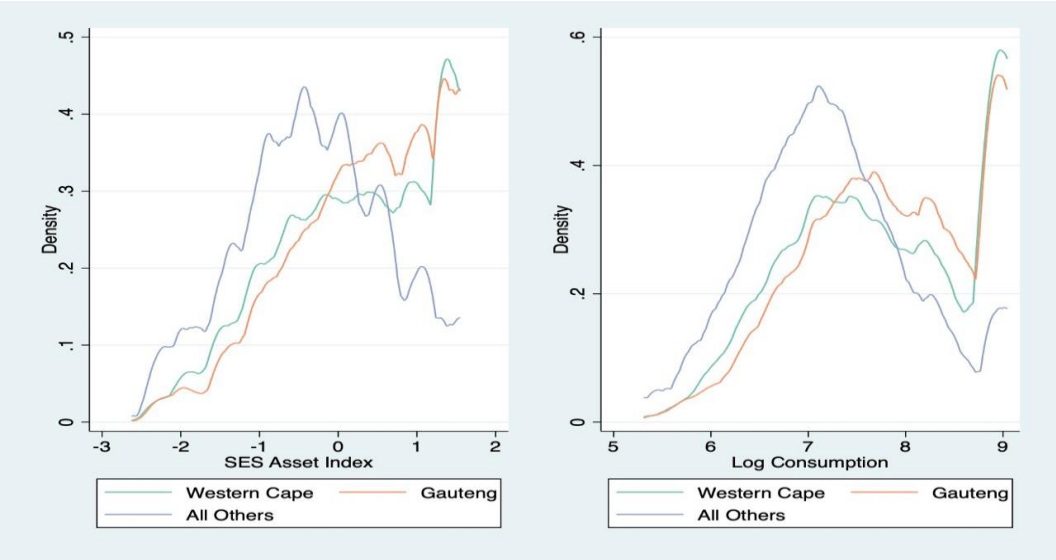
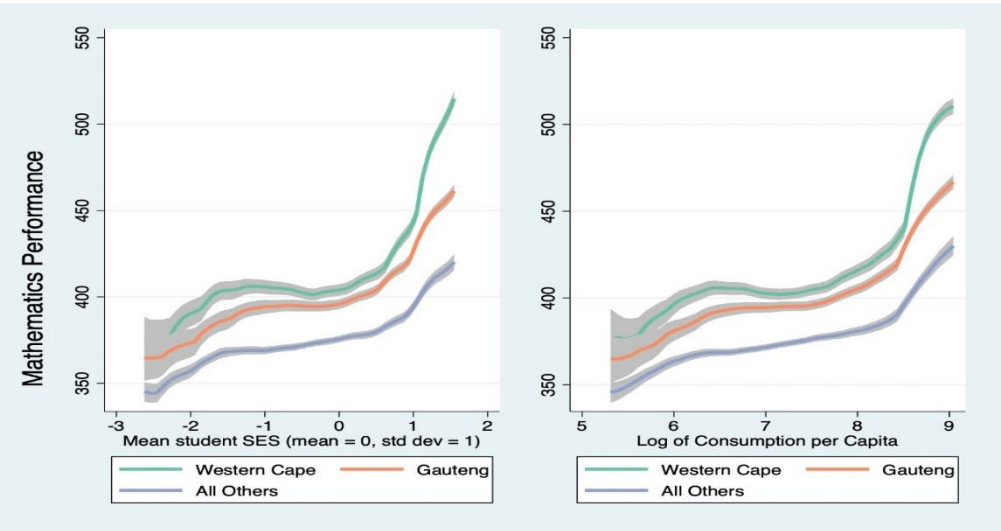


Figure 9 is a kernel density plot of the distribution of the SES asset index, as well as the log of consumption scale, for the Western Cape, Gauteng and the seven other provinces. Both indicators show that the remaining seven provinces have a relatively larger proportion of their students at the bottom and middle of the SES distribution. There are relatively much wealthier students in the Gauteng and Western Cape samples. Yet, while the SES distribution clearly favours Gauteng and the Western Cape, at every level of SES, better student results are achieved in these two provinces relative to the remaining seven. This is seen in Figure 10 which graphically presents the result of a local polynomial regression relationship between mathematics scores and an asset-based index on the x-axis on the left, and log of consumption on the x-axis on the right. At every point along the x-axis in Figure 10, it is immediately clear that Western Cape students outperform students from Gauteng and other provinces.

Figure 10: Mathematics performance by socio-economic status, by province (grade 9 TIMSS 2019)



In both instances—using SES or log of consumption on the x-axis— the shape of the relationship between grade 9 mathematics performance and economic well-being appears to be nonlinear. For both the Western Cape and Gauteng, the slope grows gradually steeper towards the higher end of the socio-economic profile, and the gap in performance gets wider. The Western Cape advantage relative to Gauteng appears to be most pronounced among the wealthiest students, agreeing with the significant differences in student performance in quintile 5 schools seen in Figure 7. Although an advantage to the Western Cape is also seen at lower SES levels. In the analysis that follows, we test whether these results hold in a multivariate regression.

It is noted that apart from the differences in scale, the shapes of the lines depicting the relationship between economic well-being and student performance are more or less the same in this regional comparison, irrespective of the SES measure used. In international comparisons however, the choice of SES scale is more context sensitive (Wills et al, 2016, 2018; O'Riordan, 2022).

5. Multivariate analysis

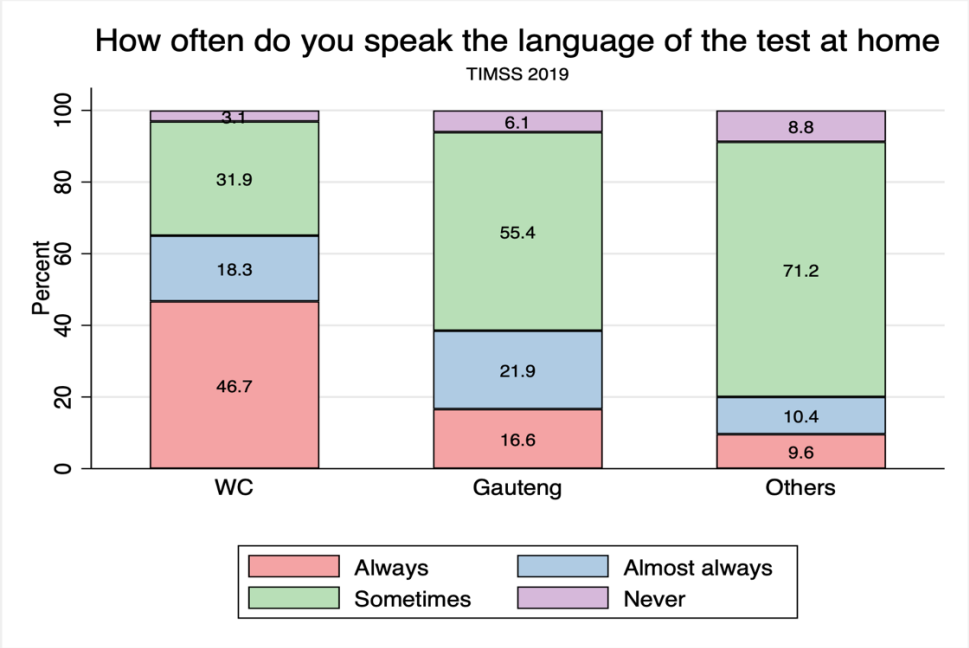
In this section, we move beyond descriptive evidence to investigate whether a Western Cape performance advantage remains relative to Gauteng, and the remaining seven provinces, after accounting for student and school resourcing differences. We have already pointed to differences in the SES of students. We now give more attention to how these education systems differ from one another with respect to other observed characteristics in TIMSS as discussed in section 5.1. In an attempt to control for these differences, and in so doing obtain a less biased estimate of the Western Cape (or Gauteng) learning effect as explained in section 5.2, section 5.3 presents the multivariate regression results.

5.1 Classroom and school resourcing differences

Tables 2 to 4 emphasise student sample differences between provincial education systems across a myriad of student background, classroom and school characteristics.

A striking advantage to Western Cape students in Table 2 (and graphically shown in Figure 11), is that they are considerably more likely to report speaking the language of the TIMSS test at home. This result is also triangulated by school principal responses, where Western Cape students' principals report the largest share of their student body speaking the language of the test at home (see Table 3). The percentage of students speaking the language of the test at home is also highly correlated with student SES.

Figure 11: Language of test spoken at home, grade 9 TIMSS 2019



Note: *WC = Western Cape

Higher student wealth in Gauteng and the Western Cape, as seen earlier in Figure 9, is matched by a larger share of fee-paying quintile 4 and 5 schools in these provinces compared with the other seven provinces. Conversely, no-fee schooling is more common in the other provinces where about 77 percent of students are in no-fee schools (quintiles 1-3) compared to 42 percent in Gauteng and 36 percent in the Western Cape.

While there are statistically significant differences in observed characteristics across the Western Cape and Gauteng samples, differences are more pronounced when comparing these two provinces to the remaining seven provinces. The Western Cape grade 9 sample includes a higher proportion of overage students relative to the Gauteng sample (26 percent vs 21 percent) although both have a smaller proportion relative to other provinces (33 percent). This high incidence of overage students in grade 9 is in line with findings by van der Berg et al. (2021) who report that between 55 - 59 percent of grade 10, 11, and 12 students are overage for their grade. Despite a higher prevalence of overage grade 9 students in the Western Cape relative to Gauteng, there have been recent improvements in internal efficiency in managing repetition patterns in the Western Cape (Van Wyk, 2021).[16]

[16] Van Wyk, (2021) investigates repetition and dropout in Western Cape schools using the Central Education Management Information System (CEMIS) datasets from 2007-2019. Despite finding evidence of considerable repetition, he identifies a significant decrease in repetition rates since 2015, particularly in grades 1 and 9, and to a lesser extent in grades 10 and 11.

Table 2: Student characteristics – comparison of means between provinces

Variable	Western Cape	SE	Gauteng	SE	Others	SE
Student Characteristics						
Age (in years)	15.5	0.03	15.3***	0.03	15.5	0.03
Overage	25.5	0.01	20.8***	0.01	32.7***	0.01
Female	55.1	0.01	55.3	0.02	50.7***	0.01
Urban	75.8	0.04	78	0.04	23.1***	0.03
Either parent has senior secondary education	30.5	0.01	23.9***	0.01	30.3	0.01
Either parent has post secondary education	17	0.01	22.2***	0.01	18.8**	0.01
Either parent has tertiary education	17.8	0.01	24.6***	0.01	16.8	0.01
Computer	63.6	0.02	64.2	0.02	40.6***	0.01
Books at home						
Few books	36.8	0.01	37.3	0.01	49.2***	0.01
An average amount	36.7	0.01	38.8	0.01	34.6*	0.01
Many books	25.9	0.019	23.6	0.01	14.8***	0.01
Unknown	0.6	0.001	0.4	0.00	1.4***	0.00
Absenteeism						
Once a week	11.6	0.01	11.2	0.01	16.3***	0.01
1 in every 2 weeks	5.1	0.00	3.4***	0.00	3.6***	0.00
Once a month	11.2	0.01	11.3	0.01	9.7**	0.01
Once every two months	11.6	0.01	11.5	0.01	7.4***	0.00
Never	59.6	0.01	61.9	0.01	61	0.01
Unknown	1.00	0.00	0.7	0.00	2***	0.00
How often you speak language of test at home						
Always	46.5	0.03	16.6***	0.02	9.5***	0.01
Almost always	18.3	0.01	21.8***	0.01	10.3***	0.01
Sometimes	31.7	0.03	55.2***	0.02	70.4***	0.01
Never	3.1	0.00	6***	0.01	8.7***	0.01
Unknown	0.4	0.00	0.4	0.00	1.1***	0.00
How often you are hungry						
Every day	17.3	0.008	18.4	0.07	16.9	0.01
Almost daily	15.1	0.006	17.3**	0.01	12.9***	0.01
Sometimes	42.3	0.008	40.5*	0.01	44.8**	0.01
Never	22.4	0.01	20.8	0.01	20.3*	0.01
Unknown	2.9	0.003	3	0.00	5.1***	0.01
How often you are tired						
Every day	12.4	0.01	11.9	0.01	10.4**	0.01
Almost daily	15.6	0.01	14.4	0.01	7.6***	0.01
Sometimes	58	0.01	57.1	0.01	56.8	0.01
Never	12.2	0.01	14.4**	0.01	22.1***	0.01
Unknown	1.8	0.00	2.3	0.00	3.2***	0.00
How often other students refused to talk to you						
At least once a week	13.7	0.01	15.3	0.01	20.9***	0.01
Once or twice a month	11.3	0.00	14.2***	0.01	15.1***	0.00
A few times a year	18.3	0.01	19.7	0.01	15.4***	0.01
Never	54.7	0.01	49***	0.01	45.3***	0.01
Unknown	2	0.00	1.8	0.00	3.3**	0.01
How often other students threatened you						
At least once a week	5.8	0.00	7.6***	0.00	11.5***	0.01
Once or twice a month	6.4	0.00	8.8***	0.01	11***	0.00
A few times a year	15.4	0.01	16.2	0.01	17.5***	0.01
Never	70.2	0.01	65.6***	0.01	56***	0.01
Unknown	2.2	0.00	1.8	0.00	4***	0.01
How often other students physically hurt you						
At least once a week/ utmost twice a month	12.9	0.01	17.7***	0.01	22.8***	0.01
A few times a year	15	0.01	15.9***	0.01	17***	0.01
Never	70.1	0.01	64.1	0.01	56.6**	0.01
Unknown	2.1	0.00	2.3***	0.00	3.7***	0.01

How often did you feel bullied						
Never	51.4	0.01	39***	0.01	30.6***	0.01
About monthly	36	0.01	46.5***	0.01	47.5***	0.01
About weekly	11.7	0.01	13.6*	0.01	20.3***	0.01
Unknown	0.9	0.00	0.8	0.00	1.7*	0.00

Source: Grade 9 TIMSS 2019 (South Africa). Own calculations. The first column of stars identifies statistical difference in mean characteristics between Western Cape and Gauteng samples. The second column of stars identifies statistical difference in mean characteristics between the Western Cape and the other seven remaining provinces. *Notes:* ∗∗∗p < 0.01, ∗∗p < 0.05, ∗p < 0.1.

Table 3: Classroom and teacher resources – comparison of means across provinces

Variable	Western Cape	SE	Gauteng	SE	Others	SE
Classroom and teacher resources						
Teacher age						
Under 25	3.8	0.01	5.6	0.01	3.4	0.01
25-29	19	0.03	16.1	0.02	17.7	0.02
30-39	21.7	0.03	20.8	0.02	24.9	0.03
40-49	20.8	0.02	31.7***	0.03	28.7**	0.03
50-59	26.7	0.03	22	0.03	21.9	0.03
60 or more	6.2	0.02	2**	0.01	1.2***	0.01
Unknown	1.9	0.01	1.7	0.01	2.3	0.01
Teacher qualification						
No degree	13.3	0.02	16.3	0.02	18.2	0.02
Degree or higher	78.1	0.03	75.5	0.03	72.4	0.03
Unknown	8.6	0.02	8.2	0.02	9.4	0.02
Is there a shortage of instructional material						
Not at all	32	0.04	27.6	0.04	11.9***	0.03
A little	30.9	0.04	18.9**	0.03	22.2*	0.03
Sometimes	22.6	0.04	22.5	0.04	40.5***	0.04
A lot	12.6	0.03	28.4***	0.04	23.3**	0.03
Unknown	1.9	0.01	2.8	0.01	2.2	0.01
Is there a shortage of calculators						
Not at all	21.6	0.03	27.7	0.04	29.4	0.04
A little	33.4	0.04	19.6***	0.03	22**	0.04
Sometimes	17.2	0.03	25.2*	0.04	22.8	0.03
A lot	26	0.04	26.7	0.04	22.8	0.03
Unknown	1.7	0.01	0.7	0.01	3	0.01
Is there a shortage of computers						
Not at all	17.1	0.03	29.5**	0.04	28.4**	0.04
A little	26.3	0.04	27.8	0.04	21.4	0.03
Sometimes	34	0.04	22.6**	0.04	22.9**	0.03
A lot	22.1	0.03	19.3	0.03	25	0.03
Unknown	0.5	0.01	0.7	0.01	2.3	0.01
How often the teacher gives student homework						
Every day	46.9	0.02	59.6***	0.02	62.5***	0.01
3/4 times a week	29.1	0.01	25.2**	0.01	20.6***	0.01
1/2 times a week	10.5	0.01	6.1***	0.01	5***	0.01
Less than once a week or never	5.9	0.01	2.8***	0.01	2.1***	0.00
Unknown	7.6	0.01	6.3**	0.01	9.8***	0.01

Source: Grade 9 TIMSS 2019 (South Africa). Own calculations. The first column of stars identifies statistical difference in mean characteristics between Western Cape and Gauteng samples. The second column of stars identifies statistical difference in mean characteristics between the Western Cape and the other seven remaining provinces. *Notes:* ∗∗∗p < 0.01, ∗∗p < 0.05, ∗p < 0.1.

Table 4: School and parental involvement characteristics – mean comparisons across provinces

Variable	Western Cape	SE	Gauteng	SE	Others	SE
School and institutional factors						
Is there a shortage of school buildings						
Not at all	43.9	0.04	28.3***	0.04	20.9***	0.03
A little	20.7	0.03	13.9	0.03	22.6	0.03
Sometimes	22.3	0.04	27.2	0.04	22.7	0.03
A lot	11.1	0.03	26.7***	0.04	29.6***	0.04
Unknown	1.9	0.01	4	0.02	4.1	0.02
Is there a shortage of teachers with a mathematics specialisation						
Not at all	39.9	0.04	24.1***	0.04	22.1***	0.03
A little	27.8	0.04	16.1**	0.03	17.8**	0.03
Sometimes	19.3	0.03	27.1	0.04	30.8**	0.04
A lot	12.6	0.03	28.5***	0.04	25.4***	0.04
Unknown	0.5	0.01	4.3**	0.02	3.9**	0.02
To what degree is teacher absenteeism a problem						
Not a problem	21.9	0.03	19.7	0.03	25.6	0.04
Minor problem	47	0.04	40.4	0.04	43.8	0.04
Moderate or serious problem	30.5	0.04	39.2	0.04	28.3	0.04
Unknown	0.5	0.01	0.7	0.01	2.3	0.01
More than half of the student body speaks the language of the test at home	57.6	0.04	26.1***	0.04	9.5***	
School Quintile						
Quintile 1	6.1	0.02	10.6	0.03	23.9***	0.04
Quintile 2	9.8	0.03	13.7	0.03	23.7***	0.03
Quintile 3	19.9	0.04	17.2	0.03	29.2*	0.04
Quintile 4	23.2	0.04	21.3	0.04	12.3**	0.03
Quintile 5	36	0.04	26.7*	0.04	7.3***	0.02
Independent schools	5.1	0.02	10.6*	0.03	2.4	0.01
Unknown	0	0.00		0.00	1.2	0.01
Parental involvement						
Level of parental commitment						
High/very high	14.2	0.03	15.9	0.03	14.3	0.03
Medium	25.4	0.04	29.8	0.04	27.8	0.04
Low/very low	59.9	0.04	53.5	0.04	56.2	0.04
Unknown	0.5	0.01	0.7	0.01	1.7	0.01
Level of parental support						
High/very high	15	0.03	19	0.03	13.5	0.03
Medium	30.8	0.04	36.4	0.04	31.6	0.04
Low/very low	52.2	0.04	43.8	0.04	53.2	0.04
Unknown	1.9	0.01	0.7	0.01	1.7	0.01

Source: Grade 9 TIMSS 2019 (South Africa). Own calculations. The first column of stars identifies statistical difference in mean characteristics between Western Cape and Gauteng samples. The second column of stars identifies statistical difference in mean characteristics between the Western Cape and the other seven remaining provinces. *Notes:* $***p < 0.01$, $**p < 0.05$, $*p < 0.1$.

Consistent with higher levels of SES among the Gauteng and the Western Cape student samples relative to the other provinces, computer access is more extensive, book ownership more common and there are vast differences in the share of students in urban areas. For example, over three quarters of students in the Western Cape and Gauteng samples reside in urban areas compared with 23 percent in the other provinces. Despite lower levels of hunger, students are more likely to report being tired in the Western Cape and Gauteng samples

compared to the other provinces. Bullying, measured in terms of a perceived sense of threat or actual threat from peers, is notably lower in Gauteng and the Western Cape than the other provinces, although Gauteng students are more likely to report bullying on most measures compared with Western Cape students.

As pertains to teacher and classroom resources, students in the TIMSS Western Cape sample are more likely than those in Gauteng or other provinces to have older mathematics teachers (aged 50 and above), although no major differences in mathematics' teacher qualifications are noted. Relative to students in Gauteng or the other seven provinces, students in the Western Cape are in schools with the lowest recorded incidence of shortages in required instructional materials but there is more of an identified need for computers. Among grade 9 students, the assignment of homework is less regular in the Western Cape.

We also consider some characteristics of the learner sample's schools that may provide crude proxies for institutional and management quality which include data on teacher absenteeism, school building shortages, and teachers with a mathematics specialisation. The Western Cape student sample are in schools with the least reported shortage of buildings or teachers with mathematics specialisation. There is 'not at all' a shortage of school buildings for 44 percent of the Western Cape sample compared to 28 percent in Gauteng and 21 percent in the remaining provinces. While about 40 percent of students in the Western Cape are in schools where there is 'not at all' a shortage of specialised mathematics teachers, this figure is 24 percent in Gauteng and 22 percent in the other provinces. Finally, we have information on parental involvement which is proxied by questions levelled to the school principal on his/her perceptions of parental commitment and support. There are no significant differences across the Western Cape, Gauteng and the other provinces on these measures.

5.2 Econometric method

Following Wills et al. (2018), we discount for observed differences across systems using a regression framework and propensity matching approach which is specified using the following education production function:

$$Y_{is} = Region_{\epsilon[WC,GP]} + \beta H_{is} + \alpha SES_{is} + \eta S_{is} + \gamma R_{is} + \delta I_s + \theta P_{is} + \varepsilon_{is} \qquad (1)$$

where Y_{is} is the test score of student i in school s, H_{is} is a vector of student and home background factors and SES is a continuous measure of socio-economic wealth and is used in conjunction with its quadratic term. S_{is} is a vector of social interaction factors, R_{is} is a vector of classroom and teacher resources, I_s is a vector of school/institutional factors and P_{is} is a vector of parental involvement factors. The primary variable of interest is $Region$ which is a fixed effect dummy variable, taking on the value of 1 for students who attended school in the Western Cape (or Gauteng in some comparisons) and 0 for students who attended school in a comparator province or provincial group. Constructed in this way, this dummy measures the difference in the expected mathematics performance for a student from the Western Cape (or Gauteng) compared to a peer in another region after controlling for relevant home background

characteristics, school and classroom characteristics, some institutional and social interaction factors and parental involvement.

While this estimation approach goes a long way in producing an unbiased estimate of expected student performance when comparing these regions, there remains a problem adequately typified by Tables 2 to 4, namely that there are significant differences in the covariate composition of these three student samples. This has implications for estimation. To facilitate such a comparison between groups characterised by different baseline characteristics, we use propensity score matching (PSM) as suggested by Rosenbaum and Rubin (1983) to improve levels of common support.

A propensity score is defined as the conditional probability of assignment of a subject to a particular treatment (in this case being in the Western Cape or Gauteng or not) given a set of observed covariates. In practice, PSM is implemented in several ways, which include matching, stratification, regression, or weighting (Dey, 2015).[17] This paper implements the propensity score weighting approach which places greater emphasis on units with propensity scores that better overlap between students, and this ensures for a comparison of more similar students. Following Wills et al (2016, 2018), propensity score weights are computed using a weighted least squares regression to ensure that the estimates derived in this analysis are between the most comparable groups of students within these regions/contexts. The resultant weights used here are one of a class of balancing weights and their associated estimand (Li, Morgan & Zaslavsky, 2018).

To illustrate, while students in the Western Cape (or Gauteng) are assigned a propensity score weight equal to 1 – e(x), students in comparator provinces are given a weight of e(x), where e(x) is the propensity score of being a grade 9 student in the Western Cape (or Gauteng) estimated from a probit regression where student and home background characteristics are regressed onto the $Region$ dummy. As in earlier and similar work by Wills et al (2018), this weighting procedure improves estimation by ensuring that comparison is done for groups that are more similar and hence more balanced on covariates. This weight is then multiplied by the TIMSS sampling weight to create a final composite weight which is used in place of the standard TIMSS survey weights (Ridgeway et al., 2015). By multiplying it to the TIMSS weight, the unique features of the TIMSS survey design are incorporated into the computation of the final composite weight. Overall, this weighting procedure improves estimation by ensuring that comparison is done for groups that are more similar and hence more balanced on covariates.

[17] While each of these methods have their advantages and disadvantages, the choice between them boils down to whether the application of these procedures can remove/reduce significant differences in baseline covariates leading to improved common support (Dey, 2015). This is often referred to as the 'balancing property'.

5.3 Econometric results

5.3.1 The Western Cape effect and expected mathematics performance

Table 5 provides estimates of the Western Cape effect in comparison to both Gauteng and the seven other provinces using grade 9 mathematics outcomes. Both tables start with very simple models that only control for the Western Cape (or Gauteng) fixed effect. In the first column, the standard TIMSS survey weights are applied. In the second model onwards, the propensity score weight is applied. From model 3 onwards, the specifications progressively expand to include socio-economic, home background, classroom, school, institutional, parental involvement, and social interaction factors. By sequentially adding a set of covariates in this manner, it is easier to separate that part in the performance gap that owes itself to the additional set of covariates.

Western Cape versus Gauteng

In column 1, the overall learning advantage that Western Cape students have over their Gauteng counterparts is consistent with the descriptive analysis discussed earlier. However, the dramatic change in the size and significance of the coefficient from column 1 to 2 allows us to appreciate how important the use of the propensity score weights is in estimating regional learning effects. The application of the propensity weights has the effect of reducing the magnitude of the Western Cape advantage relative to Gauteng, implying that for similarly resourced students and schools, the Western Cape advantage is not as large.

For all the models that make use of the propensity score weights, the Western Cape estimate is positive but small and only significant in column 8, after controlling for parental involvement factors. The results in column 8 initially imply that parental involvement and commitment may matter for improved learning. This is consistent with an earlier finding by Wills et al. (2018) which showed that the Western Cape effect among grade 6 primary school students relative to Gauteng increased after including parental factors.[18] As the coefficient is only significant at the 10 percent level and the size of the coefficient itself does not appear to change by much, we cannot claim to fully understand the way in which parental involvement directly affects education outcomes, nor confidently disentangle this effect from various other processes at play.

Western Cape or Gauteng versus seven other provinces

In relation to the remaining seven provinces, the Western Cape learning advantage is statistically different from zero in all but the model specification that adds teacher and classroom factors. In all model specifications in the Gauteng vs. seven other provinces comparison, the Gauteng coefficient is positive and statistically different from zero. As expected, there is a larger learning gap between students in the remaining seven provinces and the Western Cape than when compared to students in Gauteng. In both comparisons, once we control for SES (column 3), the size of the Western Cape and Gauteng coefficient declines substantially, implying that a significant portion of the mathematics advantage in these two

[18] In their case, the authors postulated that this advantage may have been due to a negative correlation between parental involvement and the Western Cape dummy which in turn was positively correlated to student performance.

provinces is absorbed by differences in SES. This is in line with existing research in South Africa identifying that socio-economic differences significantly account for differences in learning outcomes (see, for example, Taylor & Yu, 2009).

A further reduction in the Western Cape or Gauteng advantage is identified after adding home background variables (which include information on book possession in the home, how often the student is absent from school, and guardians' highest level of education). Together, student background factors and SES account for two thirds of the Western Cape advantage and a half of the Gauteng advantage relative to seven other provinces. The inclusion of the remaining factors does not appear to further reduce the Western Cape advantage. In other words, a significant portion of provincial gaps in mathematics outcomes merely reflect inequality of circumstance across the composition of students. Notwithstanding, even after parental involvement factors are included in the last model specification, the Western Cape and Gauteng advantages relative to the other provinces remain positive and significant (at 13 TIMSS points for the Western Cape and 7 TIMSS points for Gauteng). This implies that while the impacts of poverty are hard to circumvent, system efficiencies can lead to somewhat better learning outcomes, a finding which is even more evident in the next analysis.

Table 5: Comparing mathematics performance in Gauteng and the Western Cape relative to each other and seven other provinces, grade 9 TIMSS 2019

	1	2	3	4	5	6	7	8
Comparison Region				*Coefficient on Western Cape and Gauteng Dummy*				
Western Cape (1) vs Gauteng (0)	20.48***	5.407	8.109	2.51	1.375	6.248	7.067	8.767*
	(5.024)	(5.577)	(4.607)	(4.079)	(3.797)	(4.261)	(4.021)	(4.151)
R-Squared	0.0137	0.000948	0.234	0.408	0.437	0.499	0.53	0.535
N	10984	10532	10532	10532	10532	10532	10532	10532
Western Cape (1) vs 7 other provinces (0)	66.52***	34.28***	23.33***	9.733*	8.057*	7.3	11.98**	12.91***
	(4.982)	(4.637)	(4.375)	(4.056)	(3.870)	(4.001)	(3.854)	(3.667)
R-Squared	0.0768	0.0396	0.168	0.361	0.388	0.427	0.461	0.465
N	15196	14429	14429	14429	14429	14429	14429	14429
Gauteng (1) vs 7 other provinces (0)	46.04***	24.85***	16.22***	13.02***	12.36***	9.538**	7.189*	6.972*
	(3.854)	(4.923)	(4.132)	(3.486)	(3.283)	(3.418)	(3.571)	(3.476)
R-Squared	0.0653	0.0237	0.147	0.352	0.379	0.417	0.458	0.46
N	15478	15155	14921	14701	14701	14701	14701	14701
Weights								
TIMSS Survey Weights	X							
Propensity Weights		X	X	X	X	X	X	X
Controls								
Socio-Economic Status (Quadratic)			X	X	X	X	X	X
Student and Home Background				X	X	X	X	X
Social Interaction					X	X	X	X
Classroom and Teacher resources						X	X	X
School/Institutional							X	X
Parental Involvement								X

Notes: Estimation using five plausible values. Standard errors in parentheses. Significance at the *10%, **5% and ***1% level of significance.

5.3.2 Performance by school quintile

In South Africa, data generating processes underlying student performance differ across poorer and wealthier parts of the schooling system (van der Berg, 2008; Spaull, 2013). It may well be for example, that among wealthier students, those from the Western Cape may enjoy a learning advantage, while lower SES students experience a disadvantage. By implication, the size and direction of the Western Cape (or Gauteng) effect may vary over the range of the school socio-economic profile as seen earlier in Figure 10. For this reason, the model specifications in Table 5 are reassessed by sub-samples of school wealth as proxied by school quintile.

In Table 5, the Western Cape (or Gauteng) effect is estimated for three student sub-samples: those in quintiles 1-3 (no-fee paying) schools; and quintiles 4, 5 or independent schools (usually fee-charging schools). We also focus on the quintile 5 school comparison as a singular group. As before, the first column includes a simple regression model that uses the standard TIMSS survey weights, after which the subsequent models all make use of propensity weights, and control for home background factors, social interaction conditions, teacher and classroom factors, governance and institutional factors, and parental involvement controls.

Relative to the seven remaining provinces, there are clear learning effects in both Western Cape and Gauteng no-fee schools. After adding all controls, in quintile 1-3 schools the learning effect in favour of the Western Cape is 24 TIMSS points and 14 TIMSS points in Gauteng. In the quintile 4, 5 and independent school comparisons, however, the Western Cape and Gauteng coefficients are positive but not significant from models 2 onwards after the application of propensity weights. The quintile 5 school advantage in the Western Cape and Gauteng relative to quintile 5 performance in seven other provinces may simply reflect differences in student compositions.[19] In quintile 1-3 schools though, compositional differences explain away a much smaller proportion of the learning advantages to the Western Cape and Gauteng.

In the Western Cape-Gauteng comparison, no significant mathematics learning effect is observed among students in wealthier quintile 4, 5 and independent schools. This is consistent with Figure 7 where among quintile 4 and independent schools, performance gaps across the Western Cape and Gauteng were largely insignificant. However, in Figure 8, it appeared that the Western Cape advantage to Gauteng was most evident in quintile 5 schools and among the wealthiest of students in Figure 10. Descriptively this is true. But when balance is improved, with comparisons aligned across more similar students, there is very little Western Cape advantage for students in quintile 5 schools relative to students in Gauteng's quintile 5 schools. Only a small but significant learning advantage presents itself when controlling for student background differences. The primary differences instead occur in no-fee schools where Western Cape students perform significantly better in grade 9 mathematics compared to students in Gauteng. After adding all controls, students in no-fee schools in the Western Cape outperform their Gauteng counterparts by 11 TIMSS points. This advantage changes very little

[19] Another probable explanation for the overall level of insignificance in the wealthier school comparisons could be that the models as currently constructed, are unable to adequately capture the data generating process that characterise these wealthier sub-samples. This would lead to an appearance of insignificance whereas in the real data generating model, these factors significantly affect learning outcomes.

across models implying that compositional differences do not reduce the advantage. In summary, the Western Cape remains more efficient in serving poorer students than Gauteng province. This is consistent with findings by Wills et al (2018) estimating grade 6 mathematics (and literacy) outcomes. [20]

Table 6: Comparing mathematics performance in Gauteng and the Western Cape relative to each other and seven other provinces, by school quintile (grade 9 TIMSS 2019)

			1	2	3	4	5	6	7
Comparison Region			*Coefficient on Western Cape and Gauteng Dummy*						
Western Cape vs Gauteng		Q1-Q3	**11.17****	**14.34****	**14.24****	**13.03****	**10.49****	**11.10****	**10.67***
	Std error		(4.098)	(4.685)	(4.658)	(4.187)	(4.008)	(4.142)	(4.358)
	R-Squared		0.00708	0.0123	0.014	0.195	0.232	0.266	0.279
		Q4, Q5 & independent	**20.29****	**0.691**	**2.77**	**-2.094**	**-1.857**	**6.795**	**5.619**
	Std error		(7.643)	(8.380)	(6.728)	(5.617)	(5.224)	(6.001)	(6.643)
	R-Squared		0.0132	0.000	0.238	0.414	0.436	0.51	0.544
		Q5	**39.23****	**24.51**	**19.97***	**9.092**	**9.087**	**10.41**	**2.281**
	Std		(12.510)	(13.560)	(9.993)	(8.377)	(7.860)	(8.685)	(8.626)
	R-Squared		0.0565	0.0205	0.209	0.392	0.413	0.476	0.513
Western Cape vs 7 other provinces		Q1-Q3	**36.48*****	**31.88*****	**30.32*****	**23.71*****	**21.50*****	**21.85*****	**23.53*****
	Std error		(4.531)	(4.811)	(4.971)	(4.695)	(4.527)	(4.673)	(5.161)
	R-Squared		0.0179	0.0415	0.0487	0.209	0.244	0.271	0.281
		Q4, Q5 & Independent	**39.97*****	**0.598**	**-2.557**	**-3.385**	**-3.876**	**3.567**	**5.612**
	Std error		(9.563)	(9.343)	(8.545)	(6.153)	(5.975)	(7.348)	(7.506)
	R-Squared		0.0476	0.000	0.17	0.364	0.384	0.458	0.496
		Q5	**59.25*****	**29.52**	**17.87**	**9.744**	**8.461**	**15.32**	**10.58**
	Std error		(12.70)	(15.50)	(12.27)	(9.702)	(9.344)	(12.87)	(22.07)
	R-Squared		0.120	0.0333	0.217	0.434	0.455	0.525	0.564
Gauteng vs 7 other provinces		Q1-Q3	**25.31*****	**20.87*****	**19.26*****	**15.31*****	**14.71*****	**13.68*****	**14.92*****
	Std error		(4.290)	(4.387)	(4.407)	(3.856)	(3.698)	(4.004)	(4.059)
	R-Squared		0.0187	0.0228	0.031	0.195	0.226	0.253	0.261
		Q4, Q5 & independent	**20.02**	**8.569**	**3.241**	**5.061**	**5.149**	**4.037**	**11.24**
	Std error		(13.14)	(16.68)	(12.20)	(6.281)	(5.988)	(9.793)	(11.07)
	R-Squared		0.0176	0.00319	0.179	0.435	0.458	0.507	0.544
		Q5	**19.68***	**6.709**	**3.206**	**2.666**	**2.685**	**0.471**	**0.890**
	Std error		(8.489)	(10.62)	(9.288)	(5.799)	(5.585)	(5.837)	(6.310)
	R-Squared		0.0164	0.00188	0.134	0.360	0.384	0.460	0.479
Weights									
TIMSS Survey weights			X						
Propensity Weights				X	X	X	X	X	X
Controls									
Socio-Economic Status (Quadratic)					X	X	X	X	X
Student and Home Background						X	X	X	X
Social Interaction							X	X	X
Classroom and Teacher resources								X	X
School/Institutional									X

Notes: Estimation using five plausible values. Standard errors in parentheses. Significance at the *10%, **5% and ***1% level of significance.

[20] Among the poorer schools, the performance advantages may be driven by higher performance in quintile 3 schools in the Western Cape, which is also the largest sub-sample of the three bottom quintiles.

6. Conclusion

In this paper, an intra-country comparison of grade 9 mathematics performance reveals system efficiencies at work in Gauteng and Western Cape schools. Although student compositions vary notably across provinces, even when comparing performance across similarly resourced students, the performance advantages to Gauteng and the Western Cape remain. This is reflected in notably higher levels of grade 9 mathematics achievement in these provinces relative to seven other South African provinces, particularly in no-fee school comparisons, after controlling for student and school resourcing differences.

When comparing Gauteng to the Western Cape, a descriptive comparison of grade 9 mathematics results initially suggests better performance in the Western Cape. Yet, since these two provinces differ in terms of their student samples, it is necessary to test whether this Western Cape advantage remains when comparing performance across more similar student samples. We find that the overall advantage is eventually absorbed by differences in other student and school characteristics. Yet in no-fee charging schools, a learning effect in favour of the Western Cape relative to Gauteng remains even when comparing students of similar SES and after accounting for differences in home, classroom, school resources and parental involvement factors. This implies that schooling for the poor is somewhat more effective in the Western Cape than Gauteng, a finding that confirms earlier work by Wills et al (2018). It is noted though that the WCED have a relatively smaller proportion of no-fee paying schools to oversee and may be able to devote more capacity to oversight, accountability and support for at-risk school environments.

Despite the observed advantages to the Western Cape in this analysis relative to Gauteng, when viewing grade 9 mathematics achievement in lieu of alternate measures of system performance, the discussion highlighted that provincial ranking is dependent on what is measured (Department of Basic Education 2020). Performance advantages are also not fixed over time. It would also be remiss not to contextualise the higher performance in the Western Cape and Gauteng relative to student performance in other developed and developing countries. Grade 9 mathematics performance in these two better performing provinces fares poorly relative to the average performance of participating countries in the TIMSS sample (albeit with large representation of developed nations). But it has also been shown that at the grade 6 level, children with similar socio-economic backgrounds perform around 0.3 standard deviations better in Kenya than in Western Cape – this is roughly equivalent to a year's worth of learning (Wills et al., 2018). This reinforces how vital participation in international assessments, such as TIMSS, PIRLS and SACMEQ, is for tracking progress and establishing comparison benchmarks. This should remain a policy priority in the education sector.

As a key contribution, this paper highlights the importance of carefully considering the context in which systems are operating in making fair comparisons of school system effectiveness, even in an intra-country comparison. Relying on mean comparisons of student performance is simply not sufficient for this purpose. The characteristics of students and their schools may vary notably across contexts, with wealthier systems postured for better performance simply due to the learning advantages students derive from their wealthier home backgrounds.

Indeed, one of the immediate takeaways from this analysis is the sheer magnitude of the impact of SES in explaining performance gaps across provinces in South Africa. Overall, controlling for SES causes a sizeable and significant reduction in the Western Cape or Gauteng effect relative to the seven other provinces, and each other, although this is far less evident when restricting on quintiles 1-3 schools with more homogenous student samples across provinces. With extremely high-income inequality in South Africa (and the highest recorded Gini-coefficient of any country in the world), this affirms the long-standing narrative that advantage begets advantage (Reddy et al., 2020). This stands in contrast to what the influential 19th century education reformer Horace Mann famously hoped it to be - "the great equaliser" (Massachusetts Board of Education, 1849).

Methodologically, this paper contributes by giving attention to the challenges of moving beyond simple mean comparisons in analyses of system performance when comparator groups are so dissimilar based on observable characteristics that there is not enough "common support" over which to run multivariate estimations. We addressed this problem using propensity weights. This involved running estimates on more similar student comparator groups. Applying this approach, we typically find no significant difference in overall mathematics performance across Gauteng and Western Cape students even though mean comparisons imply an advantage to the Western Cape (but a Western Cape advantage remains in no-fee school comparisons). This implies that caution should be exercised in comparing trends in performance over time using mean differences alone. Improvements or declines in relative provincial performance may merely be an artefact of variations in the characteristics of student samples across periods.[21]

As seen in this paper, where a large proportion of the overall performance gap across provinces derives from student socio-economic differences, improving learning is not divorced from addressing issues of poverty. This presents a challenge for realising learning improvements. Creating the conditions for upward socio-economic mobility is difficult work, depending on the schooling system itself and in most instances would require more than a single generation to achieve. A learning improvement agenda, including active measures to improve the quality of teaching in schools supported through functional administrations, should happen in parallel with a programme of economic growth and poverty alleviation. Notwithstanding, the Western Cape and Gauteng advantage in no-fee schools (and even higher advantage in the Western Cape) is evidence that education systems can do better with what they have and given the poverty levels of the children they serve. This points to the continued importance of the development of state capability in educational administration in shaping the effectiveness of schooling (Gustafsson, 2019).

[21] With regards to policy, an interesting take away highlighted by this analysis is how varied the impact of schooling inputs is depending on region. For example, while parental involvement may be important in bridging the learning gap between Western Cape and Gauteng, its impact is almost negligible when comparing students from the Western Cape and the remaining provinces. This highlights the need to move away from "one-size-fits-all" type of policies in favour of more nuanced approaches that account for the idiosyncratic features of the region in question.

References

Aikens, N.L. & Barbarin, O. 2008. Socioeconomic Differences in Reading Trajectories: The Contribution of Family, Neighborhood, and School Contexts. *Journal of Educational Psychology*. 100(2). DOI: 10.1037/0022-0663.100.2.235.

Auditor-General South Africa (2016) Education Sector Report for 2015-16. Pretoria.

Bradley, R.H., Corwyn, R.F., McAdoo, H.P. & Garcia Coll, C. 2001. The Home Environments of Children in the United States Part I: Variations by Age, Ethnicity, and Poverty Status. *Child* Development. 72(6):1844-67. DOI: 10.1111/1467-8624.t01-1-00382.

Brown, M.G., Wohn, D.Y. & Ellison, N. 2016. Without a map: College access and the online practices of youth from low-income communities. *Computers & Education*. 92–93:104–116. DOI: 10.1016/J.COMPEDU.2015.10.001.

Buckingham, J., Wheldall, K. & Beaman-Wheldall, R. 2013. Why poor children are more likely to become poor readers: The school years. *Australian Journal of Education*. 57(3). DOI: 10.1177/0004944113495500.

Crouch, L. & Hoadley, U. 2018. Chapter 2: The Transformation of South Africa's System of Basic Education. In: In *The Politics and Governance of Basic Education. A Tale of Two South African Provinces* (B. Levy, R. Cameron, U. Hoadley, & V. Naidoo, Eds.) New York: Oxford University Press. DOI: 10.1093/OSO/9780198824053.003.0002.

Deloitte. 2013. Assessment of National Implementation of Post Provisioning System: National Report. Report for UNICEF and DBE.

Department of Education. 2006. *2005 Education Investment Review. Key Trends and Policy Implications.* Pretoria.

Department of Basic Education. 2016. *Report on progress in the schooling sector against key learner performance and attainment indicators.* Pretoria.

Department of Basic Education. 2020. *Action Plan to 2024. Towards the Realisation of Schooling 2030*. Pretoria.

Dey, S. 2015. Impact of remittances on poverty at origin: a study on rural households in India using Covariate Balancing Propensity Score Matching. *Migration and Development*. 4(2):185–199. DOI: 10.1080/21632324.2014.979022.

Massachusetts Board of Education. 1849. Twelfth Annual Report of the Board of Education, together with the Twelfth Annual Report of the Secretary of the Board (1848). Available: https://archives.lib.state.ma.us/handle/2452/204731 [2021, November 26].

Fan, J. & Gijbels, I. 2018. *Local Polynomial Modelling and Its Applications*. Routledge.

Filmer, D. & Pritchett, L.H. 2001. Estimating wealth effects without expenditure data—or tears: An application to educational enrolments in states of India. *Demography*. 38(1):115–132. DOI: 10.1353/dem.2001.0003.

Francis, D. & Webster, E. 2019. Poverty and inequality in South Africa: critical reflection. *Development Southern Africa*. 36(6): 788-802.

Gustafsson, M. & Taylor, S. 2018. Treating schools to a new administration: Evidence of the impact of better practices in the system-level administration of schools. *Journal of African Economies.* 27(5):515-537. DOI: https://doi.org/10.1093/jae/ejy005

Gustafsson, M. 2019. The case for statecraft in education: The NDP, a recent book on governance, and the New Public Management inheritance. *Stellenbosch Economic Working Papers* (WP16/2019).

Kotze, J. & van der Berg, S. 2019. Mathematical Performance among the Poor: Comparative Performance across Developing Countries. *International Handbook of Mathematical Learning Difficulties* (57-71).

Levy, B. 2018. Chapter 10: 'All for Education'-Meeting the Governance Challenge. In *The Politics and Governance of Basic Education. A Tale of Two South African Provinces* (B. Levy, R. Cameron, U. Hoadley, & V. Naidoo, Eds.) New York: Oxford University Press.

Li, F., Morgan, K.L. & Zaslavsky, A.M. 2018. Balancing Covariates via Propensity Score Weighting. *Journal of the American Statistical Association*. 113(521):390–400. DOI: 10.1080/01621459.2016.1260466.

Martin, M.O., von Davier, M. & Mullis, I.V. 2020. *Methods and Procedures: TIMSS 2019 Technical Report*. TIMSS & PIRLS International Study Center, Lynch School of Education and Human Development, Boston College and International Association for the Evaluation of Educational Achievement (IEA). https://timssandpirls.bc.edu/timss2019/methods/

Mislevy, R.J. 1991. Randomization-based inference about latent variables from complex samples. *Psychometrika*. 56(2):177–196. DOI: 10.1007/BF02294457.

Mislevy, R.J., Johnson, E.G. & Muraki, E. 1992. Chapter 3: Scaling Procedures in NAEP. *Journal of Educational Statistics*. 17(2):131–154. DOI: 10.3102/10769986017002131.

Mullis, I. V. S., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2020). *TIMSS 2019 International Results in Mathematics and Science.* Retrieved from Boston College, TIMSS & PIRLS International Study Center website: https://timssandpirls.bc.edu/timss2019/international-results

O'Riordan, A. 2022. Comparing mathematics achievement in South Africa and its two best performing provinces against other developing countries: An analysis of TIMSS grade 8/9 2019. HSRC working paper.

Pritchett, L. A Review Essay – The Politics and Governance of Basic Education: A Tale of Two South African Provinces. RISE, University of Oxford. Available: https://riseprogramme.org/sites/default/files/publications/20190701_Pritchett_SA_Book_Review_Insight_0.pdf [2021, November 20]

Reddy, V., Winnaar, L., Juan, A., Arends, F., Harvey, J., Hannan, S. & Zulu, N. 2020. TIMSS 2019: Highlights of the Western Cape Province Grade 9 Results in Mathematics and Science. *Achievement and achievement gaps. Department of Basic Education*.

Reddy, V., Winnaar, L., Juan, A., Arends, F., Harvey, J., Hannan, S., Namome, C., Sekhejane, P., et al. 2020. TIMSS 2019: Highlights of South African Grade 9 results in mathematics and science. Achievement and achievement gaps. Department of Basic Education.

Rosenbaum, P.R. & Rubin, D.B. 1983. The central role of the propensity score in observational studies for causal effects. *Biometrika*. 70(1):41–55. DOI: 10.1093/BIOMET/70.1.41.

Ross, K. & Zuze, L. 2004. Traditional and alternative view of school system performance. *IIEP Newsletter). IIEP Newsletter*.

Shonkoff, J. and Garner, A. 2012. The Committee On Psychosocial Aspects Of Child And Family Health, Committee On Early Childhood, Adoption, And Dependent Care. In *The Committee On Psychosocial Aspects Of Child And Family Health*, *Committee On Early Childhood*, *Adoption*, *And Dependent Care*.

Spaull, N. 2013. Poverty and privilege: Primary school inequality in South Africa. *International Journal of Educational Development*. 33(5):436–447. DOI: 10.1016/j.ijedudev.2012.09.009.

Spaull, N., Lilenstein, N. & Carel, D. 2020. The race between teacher wages and the budget. The case of South Africa 2008-2018. *Research on Socio-Economic Policy (ReSEP), Stellenbosch University*.

Ridgeway, G., Kovalchik, S.A, Griffin, B.A. and Kabeto, M. 2015. Propensity Score Analysis with Survey Weighted Data. Journal of Causal Inference. 3(2): 237-249.

Taylor, S., & Yu, D. 2009. The importance of socio-economic status in determining educational achievement in South Africa. *Stellenbosch Working Paper Series* (Issue 01/2009).

Van der Berg, S. 2008. How effective are poor schools? Poverty and educational outcomes in South Africa. *Studies in Educational Evaluation*. 34(3):145–154. DOI: 10.1016/J.STUEDUC.2008.07.005.

Van der Berg, S., van Wyk, C., Selkirk, R. & Hofmeyr, H. 2021. Learner flows through schools: Using high quality administrative data to understand education system performance. *Research on Socio-Economic Policy (RESEP) Working papers*.

Van Bergen, E., van Zuijen, T., Bishop, D. & de Jong, P.F. 2017. Why Are Home Literacy Environment and Children's Reading Skills Associated? What Parental Skills Reveal. *Reading Research Quarterly*. 52(2). DOI: 10.1002/rrq.160.

Van der Berg, S., Wills, G., Selkirk, R., Adams, C., and van Wyk, C. (2019) The cost of repetition in South Africa. *Stellenbosch Working Paper Series* (WP13/2019).

Van Wyk, C. 2021. Learner flow through patterns in the Western Cape using CEMIS datasets from 2008 to 2019: A longitudinal cohort analysis. *Stellenbosch Economics Working Paper Series* (WP01/2021).

Von Davier, M. 2020. Chapter 11: TIMSS 2019 Scaling Methodology: Item Response Theory, Population Models, and Linking Across Modes. In *Methods and Procedures: TIMSS 2019 Technical Report*. (M.O.Martin, M. von Davier, & I.V.Mullis Eds) TIMSS & PIRLS International Study Center, Lynch School of Education and Human Development, Boston College and International Association for the Evaluation of Educational Achievement (IEA). https://timssandpirls.bc.edu/timss2019/methods/

Vyas, S. & Kumaranayake, L. 2006. Constructing socio-economic status indices: how to use principal components analysis. *Health Policy and Planning*. 21(6):459–468. DOI: 10.1093/heapol/czl029.

Wills, G. Informing principal policy reforms in South Africa through data-based evidence. *South African Journal of Childhood Education.* 5(2):a392. DOI: 10.4102/sajce.v5i2.392

Wills, G., Shepherd, D. & Kotzé, J., 2016. Interrogating a Paradox of Performance in the WCED: A Provincial and Regional Comparison of Student Learning, *Stellenbosch Working Paper Series* (WP14/2016), Stellenbosch University, Department of Economics.

Wills, G., Shepherd, D. & Kotzé, J. 2018. Explaining the Western Cape Performance Paradox: An Econometric Analysis. In *The Politics and Governance of Basic Education*. *A Tale of Two South African Provinces* (B. Levy, R. Cameron, U. Hoadley, & V. Naidoo, Eds.) Oxford: Oxford University Press. DOI: 10.1093/oso/9780198824053.003.0006.

Wu, M. 2005. The role of plausible values in large-scale surveys. *Studies in Educational Evaluation*. 31(2–3):114–128. DOI: 10.1016/j.stueduc.2005.05.005.